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Application For Patent

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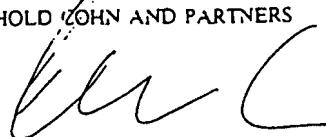
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میکوم של אלמנט אורתודונטי על גבי משטח שן

(באנגלית)  
(English)

Placing an orthodontic element on a tooth surface

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מבקשת פטנט from application	מספר No.	לבקשה/פטנט to Patent/Addon	מספר No.	מספר/סימן Number/Mark	תאריך Date	מדינת האינוד Convention Country
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Placing an orthodontic element on a tooth surface

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## PLACING AN ORTHODONTIC ELEMENT ON A TOOTH SURFACE

### FIELD AND BACKGROUND OF THE INVENTION

The present invention is generally in the field of orthodontics and provides a method, system and device for placing an orthodontic element, e.g. a bracket on the surface of a tooth of an individual undergoing orthodontic treatment or for marking the spot on a tooth where such an element should be placed.

One of the most critical steps in an orthodontic treatment is the proper placement of brackets on surfaces of teeth of treated individuals. The location of the bracket on the tooth as well as its orientation is a critical factor in determining the direction of movement of the teeth during the treatment. In current orthodontic practice, the orthodontist decides on a general scheme of placing the brackets on the teeth and then attaches each of them to the surface of a tooth, in an exact location and orientation decided at the time of such placing. Preparatory to an orthodontic treatment, the orthodontist typically prepares a plaster model of the teeth of the treated individual and on the basis of such model, the general scheme of placement of the brackets can be decided. However, there is currently no available method which will allow to position the bracket correctly on a tooth surface, based on a determination made previously, e.g. based on a model.

In orthodontic treatment, the brackets are typically placed on the buccal surface of the teeth. At times, it is desired both from a treatment perspective as well as for reasons of external appearance of the individual, to place the brackets on the lingual surface of the teeth. However, by 5 current methods it is difficult to properly position the brackets on the lingual surfaces, particularly in view of difficulties in monitoring the position during attachment of the brackets.

#### GENERAL DESCRIPTION OF THE INVENTION

10 It is an object of the present invention to provide a method, system and device for positioning of an orthodontic element on a surface of a tooth, or for marking the position, where an element has to be subsequently placed. The positioning may be based on a prior determination of the proper position of the element on a tooth.

15 The term "*position*" is used herein to denote either the element's location on the surface of a tooth, its orientation or a combination of location and orientation. The term "*positioning*" will be used to denote the act of placing the bracket on the surface of a tooth in a desired position. The term "*element*" is used herein to denote a device which is fixed on to 20 a tooth within the framework of an orthodontic treatment, e.g. a bracket.

In accordance with one aspect of the invention, there is provided a method for positioning and fixing an orthodontic element on a surface of a tooth, comprising:

- (a) mounting of the element on a positioning device;
- 25 (b) manipulating said device so as to bring the element into proximity of said surface while continuously monitoring the element by an image acquisition unit which captures the image of the element and its surroundings and transmits this image to a screen;
- (c) on the basis of the image displayed on the screen, positioning the 30 element on the tooth surface; and
- (d) fixing the element to the tooth.

In accordance with another aspect of the invention there is provided a method for marking a position on a tooth where an orthodontic element is to be placed and fixed, the method comprising:

- 5 (a) a marking device, having a marking member for making a visible mark on a tooth;
- (b) manipulating said device so as to bring it into proximity of said surface while continuously monitoring the marking member by an image acquisition unit which captures the image of the marking member and its surrounding and can switch this image to a screen;
- 10 (c) on the basis of the image displayed on the screen, fixing the position of the marking member on the tooth surface; and
- (d) marking said position.

The marking device may be a device adapted to attach a sticker to mark the position where the orthodontic element is to be fixed; adapted to make a color mark on the tooth, e.g. by stamping, so as to mark said position; etc. The marked position of the element can then serve as guidance for replacement of an orthodontic element on the surface of a tooth.

In accordance with a preferred embodiment, the positioning of the element or the marking member is guided by guidance information displayed on the screen. This allows to place the element or the marking member in a proper position, which is a position of the element on the surface of the tooth, which was previously decided to be that which will yield optimal results in the orthodontic treatment. The method according to this preferred embodiment for positioning and fixing an element on a surface of a tooth, comprises:

- 20 (a) mounting the element on a positioning device;
- (b) bringing the element into proximity of said surface while continuously monitoring the element by a image acquisition unit which captures an image of the element and its surroundings and transmits this image to a screen;
- 25 (c) displaying on the screen

- (i) said image;
- (ii) guidance information relating to a proper position of the element on said surface;
- (d) in case of discrepancy between actual position of said element, 5 being the position of the element viewed on the screen, and said proper position, correcting the actual position to match said proper position; and
- (e) fixing said element on said surface.

10 The method according to the preferred embodiment for marking a position on the surface of a tooth where an orthodontic element is to be subsequently positioned, the method comprising:

- (a) a marking device, having a marking member for making a visible mark on a tooth;
- (b) bringing the marking member into proximity of said surface while continuously monitoring the marking member by an image acquisition unit 15 which captures an image of the marking member and its surrounding and transmits this image to a screen;
- (c) displaying on the screen
  - (i) said image;
  - (ii) guidance information relating to a proper position of the 20 element on said surface;
- (d) in case of a discrepancy between actual position of said marking member, being the position viewed on the screen, and said proper position, correcting the actual position to match said proper position; and
- (e) marking said position on said surface.

25 The invention also provides a method for comparing between an orthodontic element's actual position on the surface of a tooth and a proper position, the method comprising:

- (a) monitoring the element and its surrounding by an image acquisition unit which transmits an image to a screen that displays said image;
- (b) displaying information on said screen regarding proper position 30 of said element in a manner allowing to compare between the actual and the proper position.

In accordance with a preferred embodiment of the invention the image acquisition unit, typically a small video camera or a small CCD device, is mounted on the positioning device, or the marking device, with both the image acquisition unit and the orthodontic element or the marking member being in a mutually fixed, pre-determined position, such that the element or the marking member always appearing in a fixed spot, e.g. the center, in the image displayed on the screen. Additionally, or alternatively, the image may be processed by an image processing unit which receives the image captured by the image acquisition unit and transmits it to the screen, such that in the image displayed on the screen the element or the marking member always appearing in a defined spot. This may be achieved by an image processing software which can identify the element or the marking member by its contours, by its color or reflectiveness, by other clues, e.g. markings displayed thereon, etc.

The information on proper position of the element may, for example, be displayed in the form of a virtual image of the tooth on which the element is to be fixed, e.g. in the form of lines tracing the boundaries of the tooth. The virtual image may at times be displayed on the screen super-imposed on a displayed real image of the element or the marking member and its surrounding, with the superimposition being such that when the element or the marking member is in its proper position on the tooth, the real image matches the virtual image. Additionally, said information may also be displayed in the form of lines tracing the boundaries of the tooth optionally together with lines tracing boundaries of neighboring teeth. The orthodontist or the technician which positions and fixes the element or the marking device on to the tooth, manipulates its position until such match is achieved.

Information regarding proper position may be obtained by a variety of methods. For example, it may be obtained on the basis of a virtual three dimensional computerized model of the teeth which is then used for a computerized design of the proper position. From such a model a virtual image of the teeth, which is a frontal image at an angle in which the

real image of the teeth will subsequently be captured by the image acquisition unit, can then be generated. A three dimensional virtual teeth model may be obtained, for example, in a manner described in PCT Application, Publication No. WO 97/03622, or that described in German Patent Application PCT Application, Publication No. WO 94/24957, the contents of which are being incorporated herein by reference. Additionally, an element's proper position may also be obtained from a treatment scheme planned on the basis of a physical model, e.g. a three dimensional plaster model. For example, brackets or mock-up brackets may be fixed on such a model within the framework of a treatment design, and then an image of a bracket on such a teeth model may be captured from an angle substantially the same as that of the real image of the teeth which will be captured by the image acquisition unit.

The display screen may typically be a television screen, a computer display, an eyepiece display, (e.g. fixed to the frame attached to the orthodontist's head), and many others.

The present invention also provides a system for positioning an orthodontic element or a marking device having a marking member for marking a position for subsequent placement of an orthodontic element on a surface of a tooth, comprising:

- an image acquisition unit for capturing an image of the element or the marking member and its surrounding while being positioned on the surface of the tooth; and
- a display screen comprising a display module for receiving the image captured by the image acquisition unit and displaying it on the display screen.

By preferred embodiment of the above system, the image acquisition unit, typically a small video camera fitted with a lens allowing near focus and a wide field of view, is mounted on the positioning device. In such a positioning device the element or the marking device, as the case may be, is typically held in a fixed place, and the image acquisition unit is

also fixed on said device such that the image of the element or marking device will always be in a defined place in the captured image.

The invention further provides a positioning device for positioning an orthodontic element on the surface of a tooth, comprising:

- 5        - a gripping member for holding said element and releasing it once it is fixed on the tooth surface; and
- an image acquisition unit for capturing an image of the element held on the gripping member and of its surrounding.

The invention still further provides a marking device for marking 10 a position for subsequent placement of an orthodontic element on a surface of a tooth, comprising:

- a marking member held on said marking device in a manner allowing to mark said position on a tooth surface; and
- an image acquisition unit for capturing an image of the marking 15 device and of its surrounding.

The positioning device of the invention allows to position and fix orthodontic elements in a proper position even on surfaces which are difficult to view. A particular example is placing brackets on lingual surfaces of teeth.

20       The invention will now be illustrated below by some non-limiting specific embodiments, with references to the figures in the attached drawings. The illustrated embodiments refer to positioning of a bracket, it being understood that the invention applies, *mutatis mutandis* also to positioning of other orthodontic elements.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the general design scheme of a system in accordance with the invention;

30       Fig. 2 shows a bracket positioning device in accordance with an embodiment of the invention;

Fig. 3 shows the device of Fig. 2 during the process of positioning the bracket for fixing on a surface of a tooth (the teeth being schematically represented by rectangles), illustrating also the field of view of the camera;

Fig. 4 shows the image which is displayed on the screen, wherein:

5 Fig. 4A illustrates the real image captured by the video camera;

Fig. 4B illustrates a virtual image on the proper position of the bracket; and

Fig. 4C illustrates a superimposition of the images of Figs. 4A and 4C.

Fig. 5 shows a real image as captured by the image acquisition unit 10 camera superimposed with a virtual image displayed as lines of teeth boundaries, wherein:

Fig. 5A shows the bracket not in the proper position; and

Fig. 5B shows the bracket in its proper position with the teeth borders matching the contours of the virtual image;

15 Fig. 6 illustrates another embodiment of displaying information regarding the proper position, where rather than lines tracing the boundaries of teeth, displayed are reference lines defining the teeth boundaries;

Fig. 7 shows an image similar to Fig. 5 where in this case, rather than displaying a virtual image in the form of lines tracing the boundaries of the 20 teeth, information on proper position is displayed in the manner illustrated in Fig. 6; and

Fig. 8 shows a marking device in accordance with an embodiment of the invention.

## 25 DESCRIPTION OF SPECIFIC EMBODIMENTS

Reference is first being made to Fig. 1 showing the general scheme of a system 10 in accordance with an embodiment of the invention. An image 12 captured by an image acquisition unit is transmitted comprising the first unit 12 which comprises a camera to a processor 14 which also receives proper position information 16 and transmits both to display screen 18, e.g. a television screen, a computer monitor screen, etc. The

image displayed on the screen may be captured by the image ("real life image") and may be an image displaying the proper position information, or a superimposition of both one on the other.

A bracket positioning device 20 in accordance with an embodiment of the invention is shown in Fig. 2. This device, of which only the front part is shown (the rear part where the device may be held by the orthodontist is not shown) comprises bracket grippers 22, holding a bracket 24, a video camera 26, mounted on a mount 28 integral with bracket gripper 22. Bracket 24 may be fixed at a determined place in an exact position by means of a removable pin 29. It should be noted that rather than a video camera other image acquisition units may be used, e.g., a CCD device.

As can be seen in Fig. 3, the video camera 26 is positioned such and has a field of view, represented by a circle 30, allowing to view bracket 24 (typically at the center of the real life image), and tooth 33 on which the bracket is to be fixed, as well as at least a portion of the neighboring teeth 32 and 34. It is to be noted, that for proper positioning, the camera's field of view should be wide enough to show boundaries of the tooth. This may be achieved either by insuring sufficient distance between bracket 24 and video camera 26 or alternatively by fitting camera 26 with a wide angle lens.

Fig. 4A illustrates schematically a real life image as viewed by camera 26. Seen in Fig. 4A are tooth 33, portions of neighboring teeth 32 and 34 and bracket 24 at the center, held on a bracket gripper 22. A virtual image can be seen in Fig. 4B comprising contours of tooth 33' and a portion of neighboring teeth 32' and 34' corresponding to tooth 33 and teeth 32 and 34, respectively. The virtual image displays the image of the teeth, which will be captured by the camera when the bracket will be in its proper position.

Superimposition of the two views can be seen in Fig. 4C. To attain a proper position, the bracket positioning device has to be manipulated

so as to cause the real image to tilt until matching the real life virtual images.

Fig. 5 shows a picture of an image as captured by a camera mounted on the bracket positioning device, superimposed with a virtual image in the form of lines tracing the boundaries of the teeth. Fig. 5A shows a state where the bracket is in a position other than the proper position. By repositioning the bracket until the virtual image matches the boundaries of the teeth, a proper positioning of the bracket is attained.

Fig. 6 shows an alternative manner of displaying information regarding proper position. In this case, rather than displaying the boundaries of the teeth, reference lines 60, 62 and 64 are provided which define the extreme boundaries of the teeth. In addition, optionally, bracket positioning lines 66 and 68 may also be displayed to ensure that the bracket (represented schematically by rectangle 69) is properly fitted on the bracket placer device; in a proper placement, bracket 69 will have its center on the crossing point between lines 66 and 68.

Fig. 7 shows the manner of obtaining proper positioning of a bracket in an analogous manner to that shown in Fig. 5 with Fig. 7A showing a state in which the bracket is in a position other than the proper position and Fig. 7B shows the state after changing position to reach a proper position of the bracket with the reference lines serving as guidelines.

Fig. 8 shows a marking device 70 in accordance with an embodiment of the invention. Device 70 has a pair of gripping members 72 holding between them a marking member 74 fixed in position by means of pin 76. Device 70 further comprises a video camera 78, mounted on a mount 80 integral with members 72, being positioned and having a field of view such that it faces marker member 74 essentially the center of its field of view. Marking member 74 has the general shape representing that of a bracket and has a tooth engaging surface 82, which is capable of stamping a mark on a tooth which will thereafter serve as a guidance for proper positioning and subsequent fixing of a bracket. Positioning of member 74

thus to achieve a proper position may be carried out similarly as described above in reference to Figs. 4-7.

**CLAIMS:**

1. A method for positioning and fixing an orthodontic element on a surface of a tooth, comprising:
  - 5 (a) mounting of the element on a positioning device;
  - (b) manipulating said device so as to bring the element into proximity of said surface while continuously monitoring the element by an image acquisition unit which captures the image of the element and its surrounding and transmits this image to a screen;
  - 10 (c) on the basis of the image displayed on the screen, fixing the positioning and orientation of the element on the tooth surface; and
  - (d) fixing the element to the tooth.
2. A method for positioning and fixing an orthodontic element on a surface of a tooth, comprising:
  - 15 (a) mounting the element on a positioning device;
  - (b) bringing the element into proximity of said surface while continuously monitoring the element by an image acquisition unit which captures an image of the element and its surrounding and transmits this image to a screen;
  - 20 (c) displaying on the screen
    - (i) said image,
    - (ii) guidance information relating to a proper position of the element on said surface;
  - (d) in case of discrepancy between actual position of said element, 25 being the position of the element viewed on the screen, and said proper position, correcting the actual position to match said proper position; and
  - (e) fixing said element on said surface.
3. A method for comparing between an orthodontic element's actual position on the surface of a tooth and a proper position, the method comprising:
  - 30 (a) monitoring the element and its surrounding by an image acquisition unit which transmits an image to a screen that displays said image;

(b) displaying information on said screen regarding proper position of said element in a manner allowing to compare between the actual and the proper position.

4. A method according to any one of Claims 1-3, wherein said 5 element is an orthodontic bracket.

5. A method according to Claim 2 or 3 wherein the information regarding the proper position of the element comprises a virtual image of the tooth.

6. A method according to Claim 5, wherein the virtual image 10 comprises lines tracing boundaries of the tooth.

7. A method according to Claim 5 or 6, comprising superimposing the virtual image with a real image captured by the image acquisition unit displayed on the screen.

8. A method according to any one of Claim 1-7, wherein the image 15 acquisition unit is mounted on the positioning device.

9. A method according to Claim 8, wherein the element is held on by said device in a fixed, predetermined position.

10. A method according to Claim 9, wherein the position of the element is such so that the element appears in the center of the image 20 displayed on the screen.

11. A method for marking a position on a tooth where an orthodontic element is to be placed and fixed, the method comprising:

(a) a marking device, having a marking member for making a visible mark on a tooth;

25 (b) manipulating said device so as to bring it into proximity of said surface while continuously monitoring the marking member by an image acquisition unit which captures the image of the marking member and its surrounding and can switch this image to a screen;

(c) on the basis of the image displayed on the screen, fixing the 30 position of the marking member on the tooth surface; and

(d) marking said position.

12. A method according to Claim 11, comprising:

- (a) a marking device, having a marking member for making a visible mark on a tooth;
- 5 (b) continuously monitoring the marking member by an image acquisition unit which captures an image of the marking member and its surrounding and transmits this image to a screen;
- 10 (c) displaying on the screen
  - (i) said image,
  - (ii) guidance information relating to a proper position of the element on said surface;
- 15 (d) in case of a discrepancy between actual position of said marking member, being the position viewed on the screen, and said proper position, correcting the actual position to match said proper position; and
- (e) marking said position on said surface.

13. A method according to Claim 12, wherein the information regarding the proper position of the element comprises a virtual image of the tooth.

14. A method according to Claim 13, wherein the virtual image comprises lines tracing boundaries of the tooth.

15. A method according to Claim 13 or 14, comprising superimposing the virtual image with a real image captured by the image acquisition unit displayed on the screen.

16. A system for positioning of an orthodontic element or a marking device having a marking member for marking a position for subsequent placement of an orthodontic element on a surface of a tooth, comprising:

- an image acquisition unit for capturing an image of the element or the marking member and its surrounding while being positioned on the surface of the tooth; and
- 30 - a display screen comprising a display module for receiving the image captured by the image acquisition unit and displaying it on the display screen.

17. A positioning device for positioning an element on the surface of a tooth, comprising:
  - a gripping member for holding the element and releasing it once it is fixed on the tooth surface; and
- 5 - an image acquisition unit for capturing an image of the element held on the gripping member and of its surrounding.
18. A device according to Claim 17, wherein the element and the image acquisition unit are mutually fixed such that said element appears in a predetermined spot of the image captured by the image acquisition unit.
- 10 19. A marking device for marking a position for subsequent placement of an orthodontic element on a surface of a tooth, comprising:
  - a marking member held on said marking device in a manner allowing to mark said position on a tooth surface; and
  - an image acquisition unit for capturing an image of the marking device and of its surrounding.
- 15 20. A device according to Claim 19, wherein the marking member and the image acquisition unit are mutually fixed such that said member appears in a predetermined spot of the image captured by the image acquisition unit.

For the Applicants.  
REINHOLD COHN AND PARTNERS  
By:

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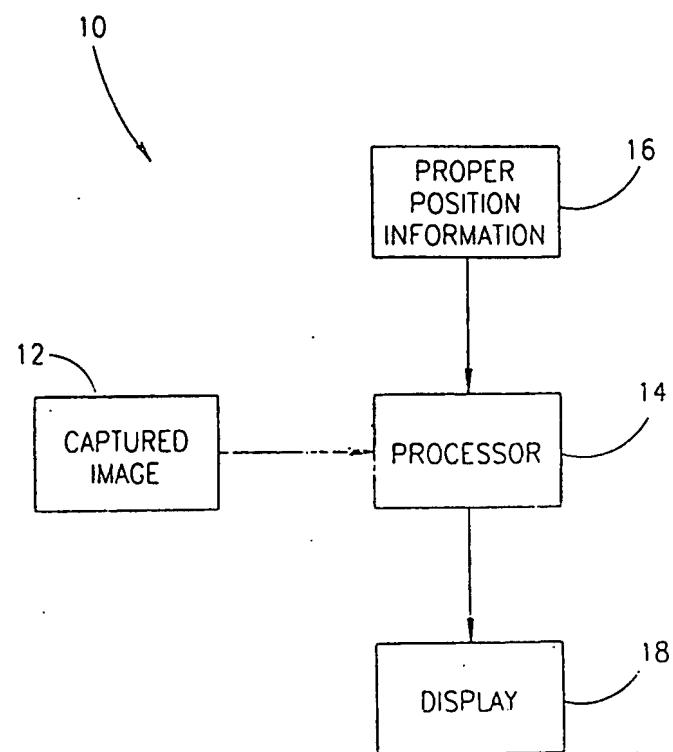


FIG.1

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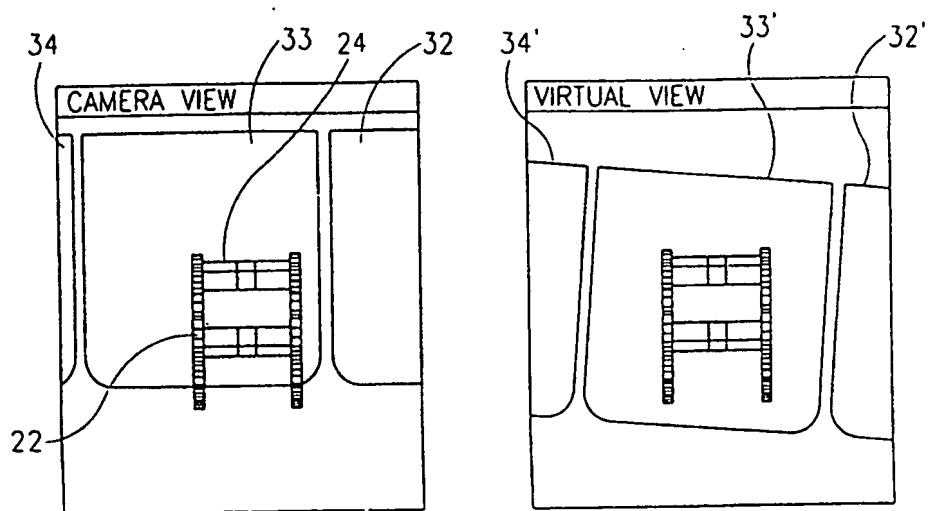


FIG.4A

FIG.4B

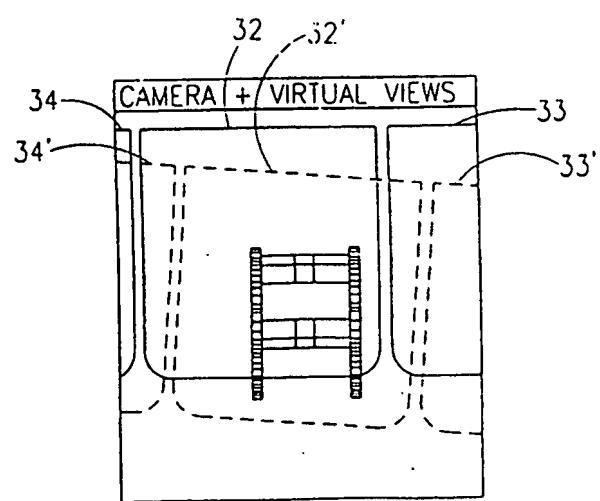


FIG.4C

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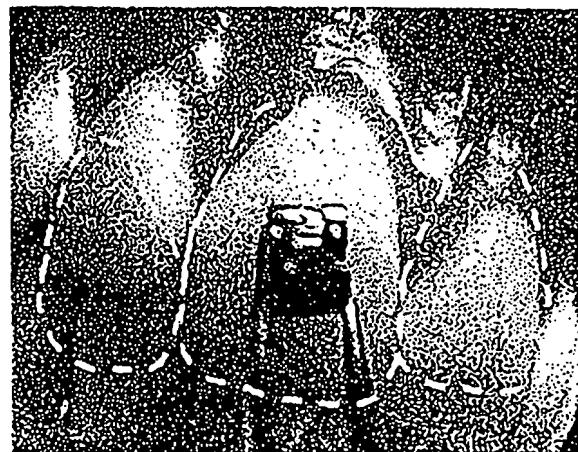


FIG.5A

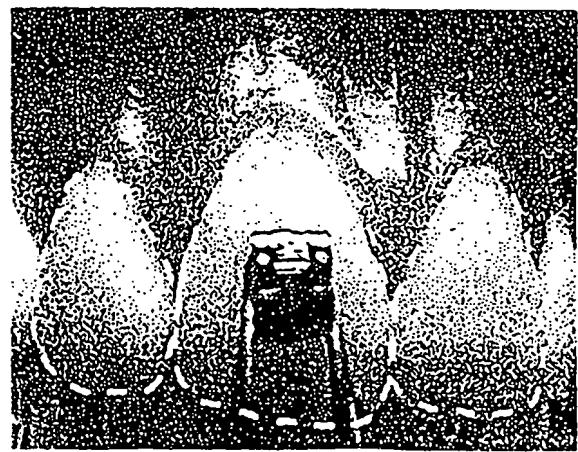


FIG.5B

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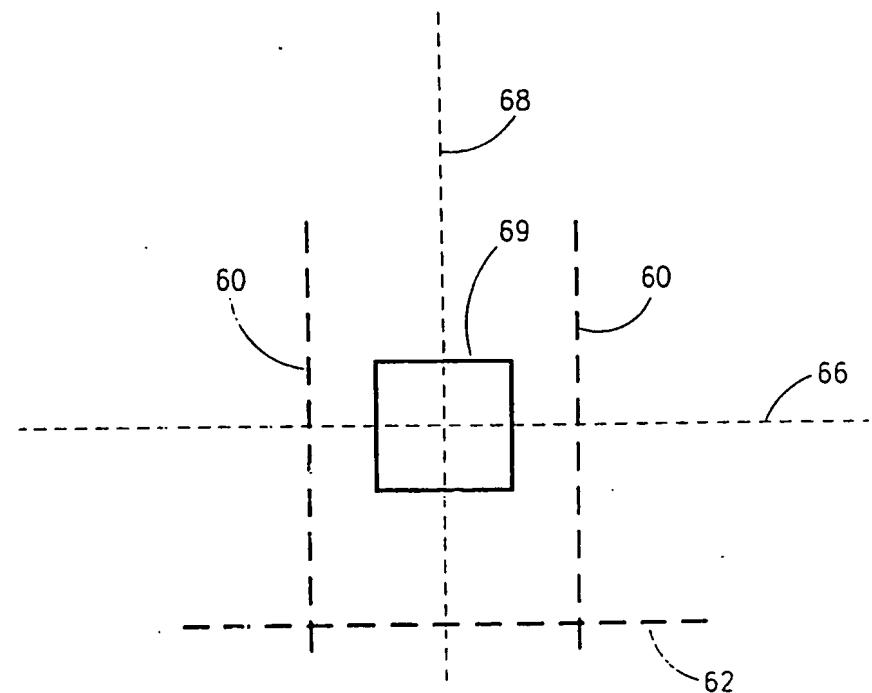


FIG.6

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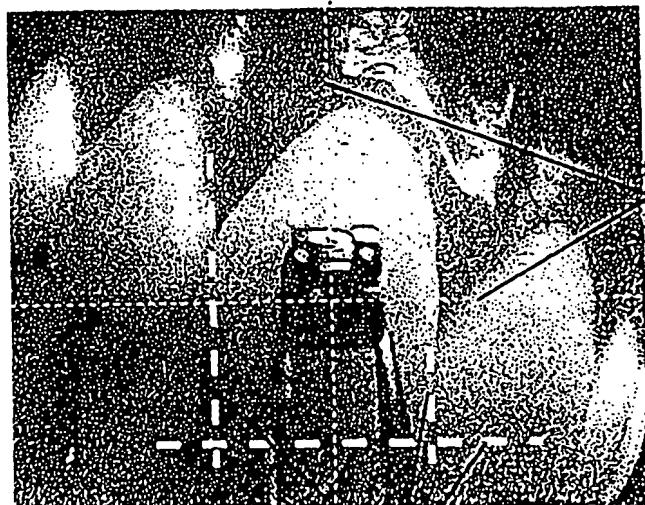


FIG.7A

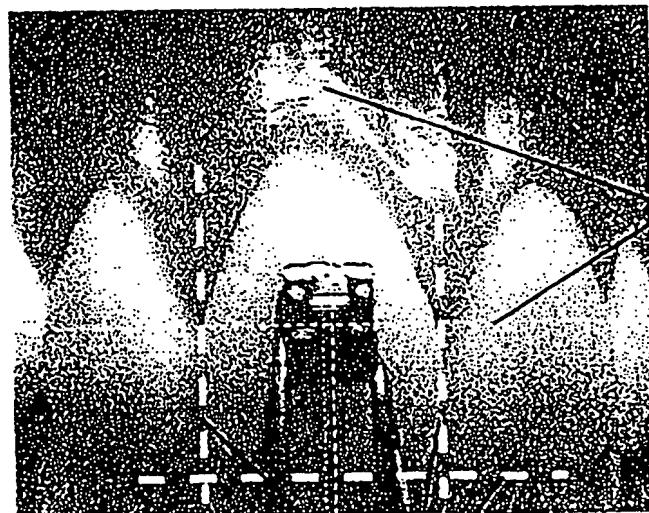


FIG.7B

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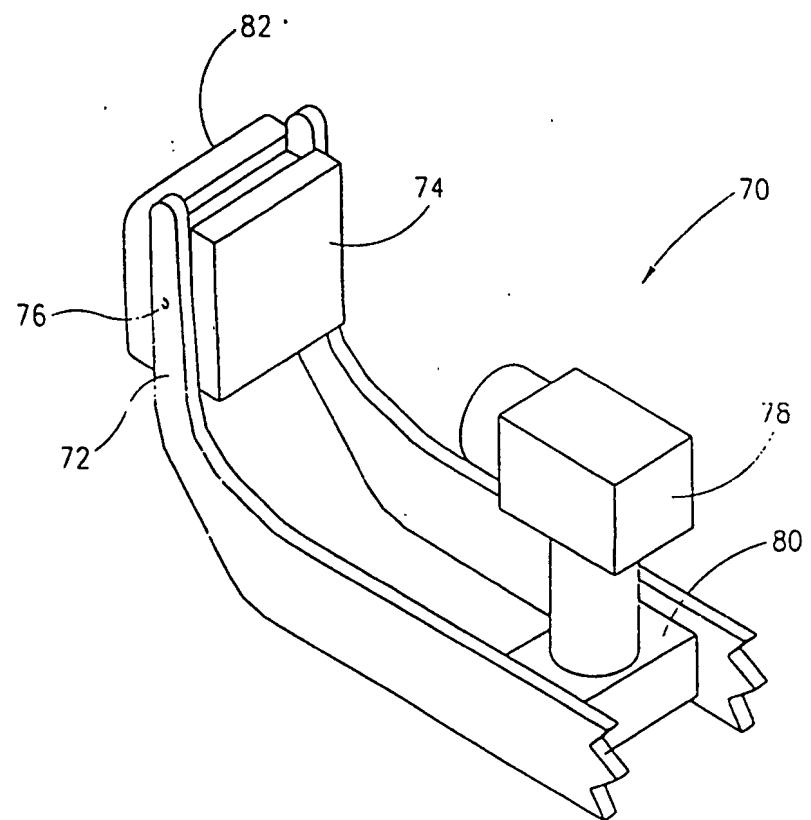


FIG.8